Food By-products & Wastes

✓ Considered as a matter of *treatment*, *minimization* & *prevention* for more than 40 years

✓ Defined as “*wastes*” in most European Legislations (442/1975/EEC, 689/1991/EEC, 98/2008/EEC) due to the fact that they removed from the production line as undesirable materials

✓ The current challenge commands their valorization as *a source of high-added value components*
Food By-products & Wastes

**Why?**

- Enormous amounts of food waste are discharged worldwide

- Existing technologies promise the *recovery* & *sustainability* of high added-value ingredients inside food chain

**But**

- Despite the omnipresence of high quality studies & patented methodologies, *market products are still rather limited*
What are the Innovation Barriers?

- Industrialization of such processes like:
  - laboratory research,
  - transfer to pilot plan & full-scale production,
  - protection of intellectual properties,
  - development of definite applications,
  - commercialization problems
  - in some cases approval of products' health claims

- Necessary issues to ensure *sustainability, economic benefit* for the involved food industry & *establishment* of the derived products *in the market*
What are the Innovation Barriers?

1) Waste collection in the source

- Requires additional transportation cost & control of microbial growth

- *Proper management* of collection process, cooling/freezing of the material, addition of chemical preservatives can provide solutions

2) Broad content variations of bioresources

- Biomaterial specifications change from time to time
- Final product’s character or functionality is altered
- Mass & energy balances restrictions

- Adding a *pre-treatment* step
Scale up

✓ Accompanied with a rapid development of complex interactions
  • Extensive handling
  • Increased air incorporation
  • Transition of batch to continuous processes

✓ Target compounds receive a higher degree of scrutiny, which results in partial loss of product functionality

✗ Drawback

Recovered compounds are used in foods at higher concentrations compared to the predicted ones
  • Organoleptic character is altered
  • Process cost is increased

✓ Limiting factors such as mixing & heating time can affect the quality
Commercial Implementation

✓ Only if a certain degree of flexibility & alternative choices can be adapted in the developing methodology

✓ Simplified processes with fewer steps
  • tend to **scale-up easier**
  • possess a **cheaper production**

✗ A project focused on the recovery technologies without establishing definite applications of the final product, is **doomed to fail**:

  • the final product might **not be as beneficial** as it has been proposed
  • difficult **to survive competition** as a non-specific functional ingredient
Market Release Permission

- Safety of active compounds recovered in *pure form*
  - Checked similarly to synthetic antioxidants
  - Long & sophisticated assays on different laboratory animals

- Safety of active compounds recovered in *natural extracts*
  - Criteria are not so strict
  - They are considered as inherent food components

- **Concentration** of compounds in crude extracts is *lower*

- **Co-extracted ingredients** affect negatively the taste
Market Needs For Healthier Products

✓ Consumers increasingly display a **preference for natural entities**, which have been generated without human intervention

✓ They require **environmental-friendly food products** that are closely tailored to their individual preferences & well-being

✓ Promotion of the "**green**" marketing & quality assurance concepts, e.g. "**organic**" & "**Protected Designation of Origin**" products

✓ Food safety concerns, health risks, complexity of globalized food chains & depletion of food resources create a **challenging environment for food innovators**
Market Barriers For Healthier Products

✓ Authorities around the world (i.e. EFSA) have tightened up the way in which companies can advertise health benefits

✓ Policy is driven by the need of protecting consumers from dubious claims

✓ Health claims have only been approved for few compounds (i.e. hydroxytyrosol in olive oil) & products (i.e. cholesterol-reducing yogurts)

✓ Demonstration of proven health benefits is very costly (too many required data)

✓ Implications for stifling innovation in the field, as most start-up companies cannot afford the respective research

✓ Risk of claims rejection

✓ Establishment of a new label (i.e. similar to organic foods or similar to carbon emission labels or ecological footprint labels)
Recommendations

✓ Implementation of non-thermal technologies, addition of green solvents & safer materials (possessing GRAS-status)

✓ Development of tailor-made applications for the recovered products

✓ Include both recovery protocols & preservation assays

✓ Clearly define the manufacturing & quality control criteria related to composition & content range of active substances as well as manufacturing development of the product

✓ A clearer label of the products containing recovered compounds would enable nutritionists to be more confident when recommending these products
Commercialized Applications

**Citrus Peel**

- One of the first wastes that has been utilized for recovery purposes
- Essential oils, flavonoids, sugar & pectin via sequential solvent extraction
- Industrial exploitation of citrus peel accounts for 30 years
- The derived product “sugar syrup” used as natural sweetener in foods instead of artificial aspartame or saccharine
- Enhances *sweetness* & *flavor* of juices
Commercialized Applications

**Natural Shrimp & Crab Shells**

- Valorized as a rich source of food grade *chitosan* (>85%) which is extracted in practice with alkali & chloroacetic acid treatment

- Sold as *thickener* in vegetable oils or as *anti-rancidity agent* in meat products
## Table 1: Commercialized methodologies

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Source</th>
<th>Tomato waste</th>
<th>Shrimp &amp; crab shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant/Company</td>
<td>Tropicana Products Inc. (Florida, USA)</td>
<td>Biolyco SRL (Lecce, Italy)</td>
<td>Qingdao Zhengzhongjiahe Export &amp; Import Co., Ltd. (Shandong, China)</td>
</tr>
<tr>
<td>Title</td>
<td>Treatment of citrus fruit peel</td>
<td>Process for the extraction of lycopene</td>
<td>Preparation of chitosan derivative fruit &amp; vegetable anti-staling agent</td>
</tr>
<tr>
<td>Product/Brand names</td>
<td>Sugar Syrup</td>
<td>Lycopene</td>
<td>Chitosan (&gt;85%), food grade</td>
</tr>
<tr>
<td>Commercialized applications</td>
<td>Food natural sweetener</td>
<td>Food Antioxidant &amp; supplement</td>
<td>Food thickener &amp; fruit anti-staling agent</td>
</tr>
</tbody>
</table>
Commercialized Applications

**Cheese Whey**

- **Lactose** is utilized as a supplement in diet food or aroma stabilizer
- Lactose can hydrolyzed to produce a saccharide containing syrup used as *sweetener*
- Whey protein isolates are prepared in *nutritional supplements* & disposed to the market by targeting *athletes*
- Whey proteins addition in foods (i.e. yoghurts) is beneficial due to their ability to *reduce total & LDL-cholesterol levels* in mammals
Table 2: Commercialized methodologies

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Cheese whey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant/Company</td>
<td>Alfa-Laval Food Engineering (Lund, Sweden)</td>
</tr>
<tr>
<td>Title</td>
<td>Method for obtaining high-quality protein products from whey</td>
</tr>
<tr>
<td>Product/Brand names</td>
<td>( \alpha )-lactoalbumin &amp; ( \beta )-lactoglobulin</td>
</tr>
<tr>
<td>Commercialized applications</td>
<td>Food Supplements</td>
</tr>
</tbody>
</table>

- **Whey protein isolate** is the most common ingredient derived from food wastes
- A typical example of target compounds complete valorization
Commercialized Applications

Olive Mill Waste (OMW)

✓ The valorization of OMW as a source of phenols is the new trend

✓ Commercial *hydroxytyrosol* isolation (Crea, 2002):

- OMW acid treatment
- incubation
- Supercritical fluid extraction
- Freeze or spray drying

✓ A countercurrent mode-column
✓ A barrier (*membrane*) interface between hydroxytyrosol containing fluid & dense gas

✓ The obtained material is a *GRAS-certified product* used as functional supplement or food preservative
Table 3: Commercialized methodologies

<table>
<thead>
<tr>
<th>Project Characteristics</th>
<th>Olive mill waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applicant/Company</td>
<td>CreAgri, Inc (Hayard, USA), Genosa I+D S.A. (Malaga), Phenoliv AB (Lund, Sweden)</td>
</tr>
<tr>
<td>Title</td>
<td>Obtaining a hydroxytyrosol-rich composition from vegetable water, Obtaining a purified hydroxytyrosol from products &amp; by-products derived from olive tree, Olive Waste Recovery</td>
</tr>
<tr>
<td>Product/Brand names</td>
<td>Hydroxytyrosol/Hidrox®, Hydroxytyrosol (99.5%)/Hytolive®, Olive phenols &amp; dietary fibers containing powders</td>
</tr>
<tr>
<td>Commercialized applications</td>
<td>Food supplements &amp; cosmetics, Conserving foods, functional ingredient in bread, Natural antioxidants in foodstuff &amp; fat replacement in meatballs, respectively</td>
</tr>
<tr>
<td>Project Characteristics</td>
<td>Source</td>
</tr>
<tr>
<td>-------------------------</td>
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</tr>
<tr>
<td>Applicant/Company</td>
<td>Yantai Andre Pectin Co. Ltd. (Yantai, China)</td>
</tr>
<tr>
<td>Title</td>
<td>Process for extracting non-pectin soluble pomace dietary fibers</td>
</tr>
<tr>
<td>Product/Brand names</td>
<td>Apple dietary fiber granules</td>
</tr>
<tr>
<td>Commercialized applications</td>
<td>Dietary supplement</td>
</tr>
</tbody>
</table>
Meat processing by-products

**Fifth Quarter**

- All the *non-meat parts of a carcass* (i.e. blood, fat, stomach, tendons, membranes etc) & animal by-products

- Rich sources of valuable components such as *protein, lipids, minerals* etc. which in their own right can command a higher value than the original source material (i.e. blood plasma proteins are higher value than blood)

- An important aspect of recovery of additional value from meat processing is adherence to the *strict legislation associated with animal by-products*

- *New regulations* make provision for the introduction of new technologies or methods for the *authorisation of such operations*
<table>
<thead>
<tr>
<th>ABP</th>
<th>Direct preparation</th>
<th>Uses</th>
<th>Revalorizing techniques</th>
<th>High added-value products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>Frozen, fresh or refrigerated</td>
<td>Braised, broiled, fried, patty &amp; sausage</td>
<td>Enzymatic hydrolysis</td>
<td>Antioxidant peptides</td>
</tr>
<tr>
<td>Heart</td>
<td>Whole or sliced or Frozen, fresh or refrigerated</td>
<td>Braised, cooked, luncheon meat, patty, loaf</td>
<td>Isoelectric Solubilization/Precipitation</td>
<td>Protein with low ash, fat &amp; cholesterol</td>
</tr>
<tr>
<td>Skin</td>
<td>Fresh, refrigerated</td>
<td>Gelatin</td>
<td>Collagen recovery Enzymatic hydrolysis &amp; chromatographic purification</td>
<td>Antioxidant peptides, Antimicrobial, antihypertensive, biomimetic tissue</td>
</tr>
<tr>
<td>Blood</td>
<td>Fresh or refrigerated</td>
<td>Black pudding, sausages, blood &amp; barley loaf</td>
<td>Enzymatic hydrolysis Ethanol precipitation Subcritical water hydrolysis</td>
<td>Purified protein as food ingredient Peptides &amp; biopreserved blood</td>
</tr>
<tr>
<td>Bone</td>
<td>Frozen, fresh or refrigerated</td>
<td>Gelatin, soup, jellied products</td>
<td>Subcritical water Alkaline extraction</td>
<td>Hydroxyapatite &amp; collagen New kind of sausages</td>
</tr>
<tr>
<td>Lung</td>
<td>Frozen, fresh or refrigerated</td>
<td>Blood preparations, pet food</td>
<td>ISP &amp; membrane filtration</td>
<td>Protein concentrates with good functional properties</td>
</tr>
<tr>
<td>Feathers &amp; hair</td>
<td>Incineration, rendering Feather or hair meal</td>
<td>Keratinolytic bacteria fermentation</td>
<td>Keratinolytic protease production</td>
<td></td>
</tr>
</tbody>
</table>
Figure: Percentage of Fifth Quarter tissue weights relative to total live weight of bovine, ovine & porcine.
Resources
Scope

To create an expert network to fill in the gap between academic research, regulatory, & food industry to enhance at high value-added compounds existing from agriculture by waste & food wastes, special emphasis towards a focus on all innovation people from academia & food industry as well as dedicated expertise in social contributions & collaborations.

Industry Training

- Training courses on food waste recovery aspects
- Workshops & seminars
- Consultative services
- Mentoring for the valorization of food by-products & as a source of raw materials

Collaborations

- Synthesis of methodologies, ideas & scale up improvements
- Encouraging experts
- Technical products derived from food by-products
- Investigating applications of recovered compounds in the food industry

Joint Calls

- Bringing together academia & industrial partners & SMEs
- Organizing common research activities
- Organizing consultations
- Submitting joint proposals to European calls (i.e. LIFE, H2020, EIT Food, etc.)
- Dissemination activities

Publications

- Preparing issues in the field of food waste recovery
- Preparing common research articles
- Supporting special issues in high-impact journals

- Implementation

Information

☑️ Training for the industry (seminars, webinars, e-learning course, workshops)

☑️ Consulting services, collaborations, joint proposals, common publications

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